SnowEx 2017: Senator Beck Basin

Overview of Year 1 field activities in the San Juan Mountains

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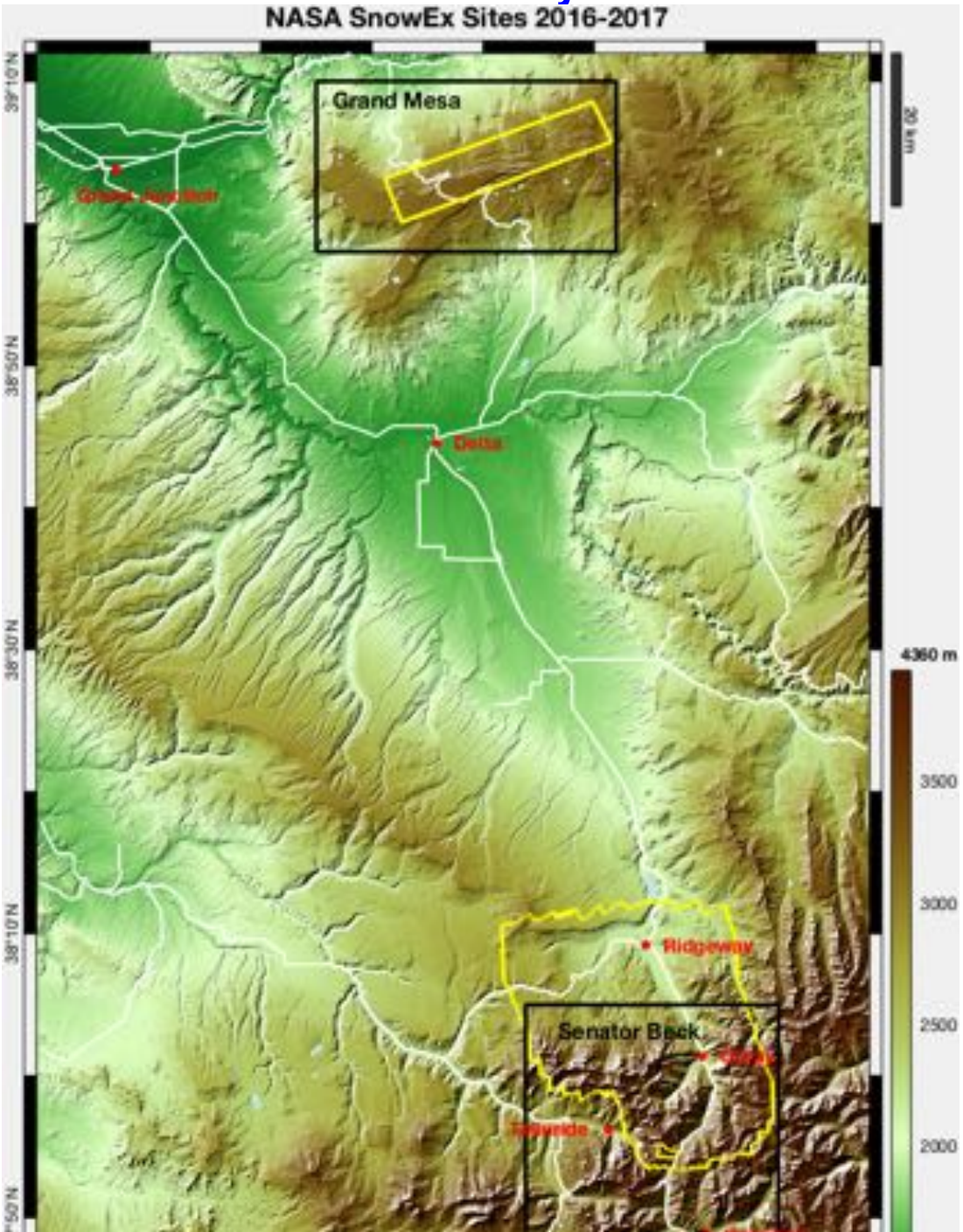
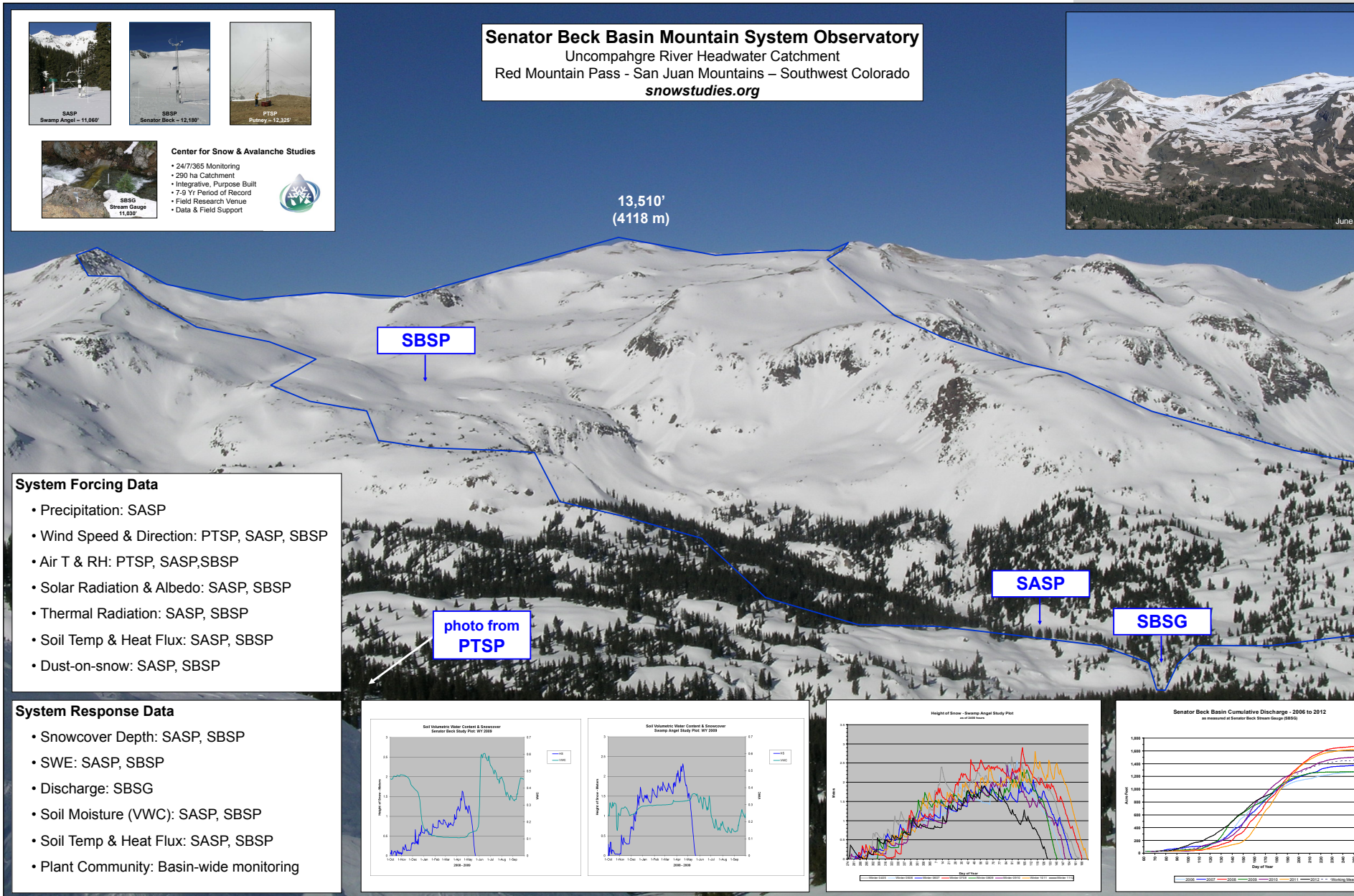
Team Senator Beck

- SnowEx 2017 Weeks 1 and 3
- 10 field scientists per week
- avalanche ed. and BC experience req.
- Core of 6 participated in both weeks
- GBRS and in-situ observations

SnowEx 2017 Year 1 Study Sites



Senator Beck Basin, Center for Snow and Avalanche Studies



Custom weather and avalanche forecast for SBB

TRAUTNER GEOTECH LLC
GEOTECHNICAL ENGINEERING, MATERIAL TESTING
AND ENGINEERING GEOLOGY

AVALANCHE and WEATHER FORECAST:
SnowEx- Senator Beck / Swamp Angel

Date: February 20, 2017	Time 6:00 am	Forecaster AG

WEATHER FORECAST: Weather Discussion
Clouds are thinning out early this morning, any lingering showers will fade away shortly after dawn, and skies should become mostly clear across the mountains by Monday afternoon. Temperatures will be mild, and ridge top winds gusty. We will be under zonal, upper-level flow through Tuesday. A storm system will pass by to our north. The storm tracks shifts southward on Wednesday, and looks like it will begin a few days of unsettled, snowy weather.
At 5:00 , Swamp Angel Temp 10 F, Winds W2- G 6. Sen Beck Temp 14 F, NW9 G 16. RMP got 4" of snow with 0.3"SWE

DAY	SNOW/WEATHER	WINDS (mph)	TEMP Hi/Low (°F)
2-20-17	**Possible lingering snow early, then mostly sunny**	**NW 10-20 G30**	**27/19**
2-21-17	**Partly cloudy, chance for snow Tues night**	**S-SE 10-15**	**32/22**
2-22-17	**Chance for snow early then partly cloudy**	**W10-20**	**30/15**

AVALANCHE FORECAST: Valid through: **DATE/TIME 2-21-17/6:00**

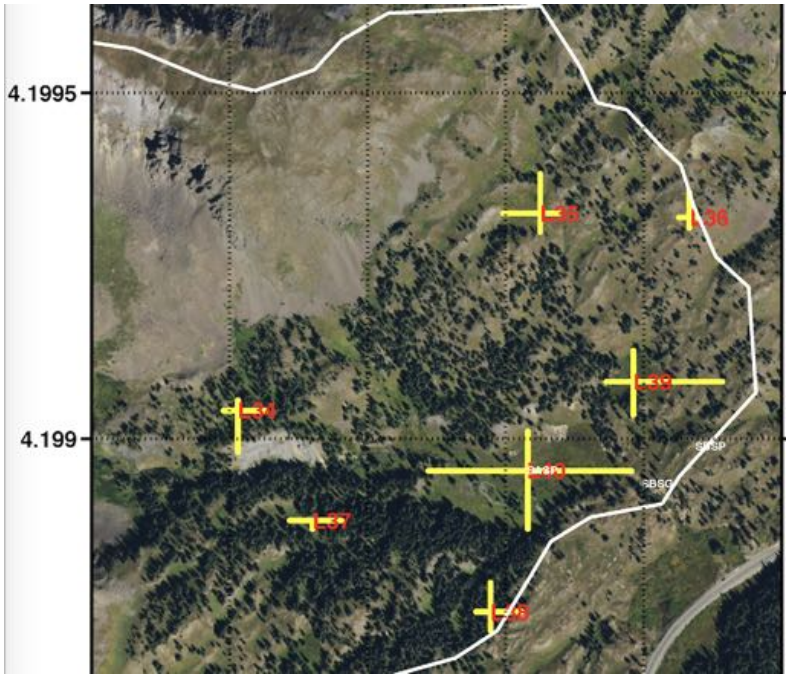
Area	CURRENT POTENTIAL	24 HR POTENTIAL
Red Mt Pass/ Swamp Angel	**LOW**	**LOW**
Sen Beck, HWY 550 to Study Plot	**MODERATE**	**MODERATE**
Sen Beck Above Study Plot	**MODERATE**	**MODERATE**

RECOMMENDATIONS:
Swamp Angle Study Plot: OPEN travel with caution
Senator Back Basin: HWY 550 to Study Plot (11,100'-12,186'): OPEN, travel with caution.
Senator Beck Basin: above Study Plot (from 12,186'-13,500'): **OPEN, travel with caution.**

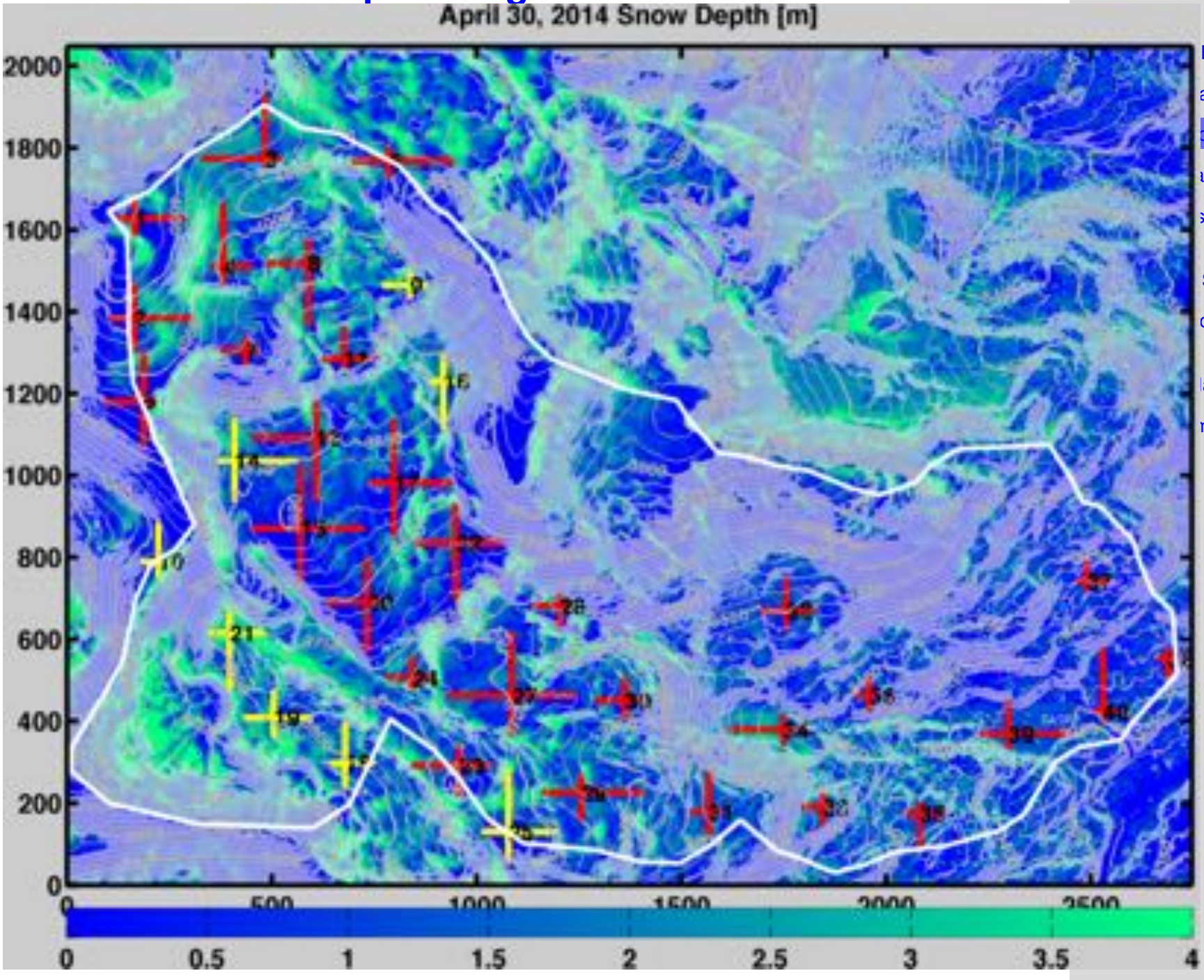
SNOWPACK: As of 5:00am this morning RMP had received 4/0.3" HN/SWE.. The basin received about 8 inches of snow last Tuesday Feb. 14 and about 2 inches on Friday. Skies reported some surface sloughing on Sunday but no slab activity. 2 test pits along the uptrack to Senator Beck on Sunday: on a 27 degree slope at 11,900 feet on SE aspect, HS 120cm; a CT ran below a suncrust CT11 10cm below the surface on a weak layer of new snow and near surface facets. At the crux, 12,000 feet on an ESE aspect, 37 degree slope, HS 212cm; I encountered 3 melt freeze crusts in the top 20 cm of

Pit and Transect sample design

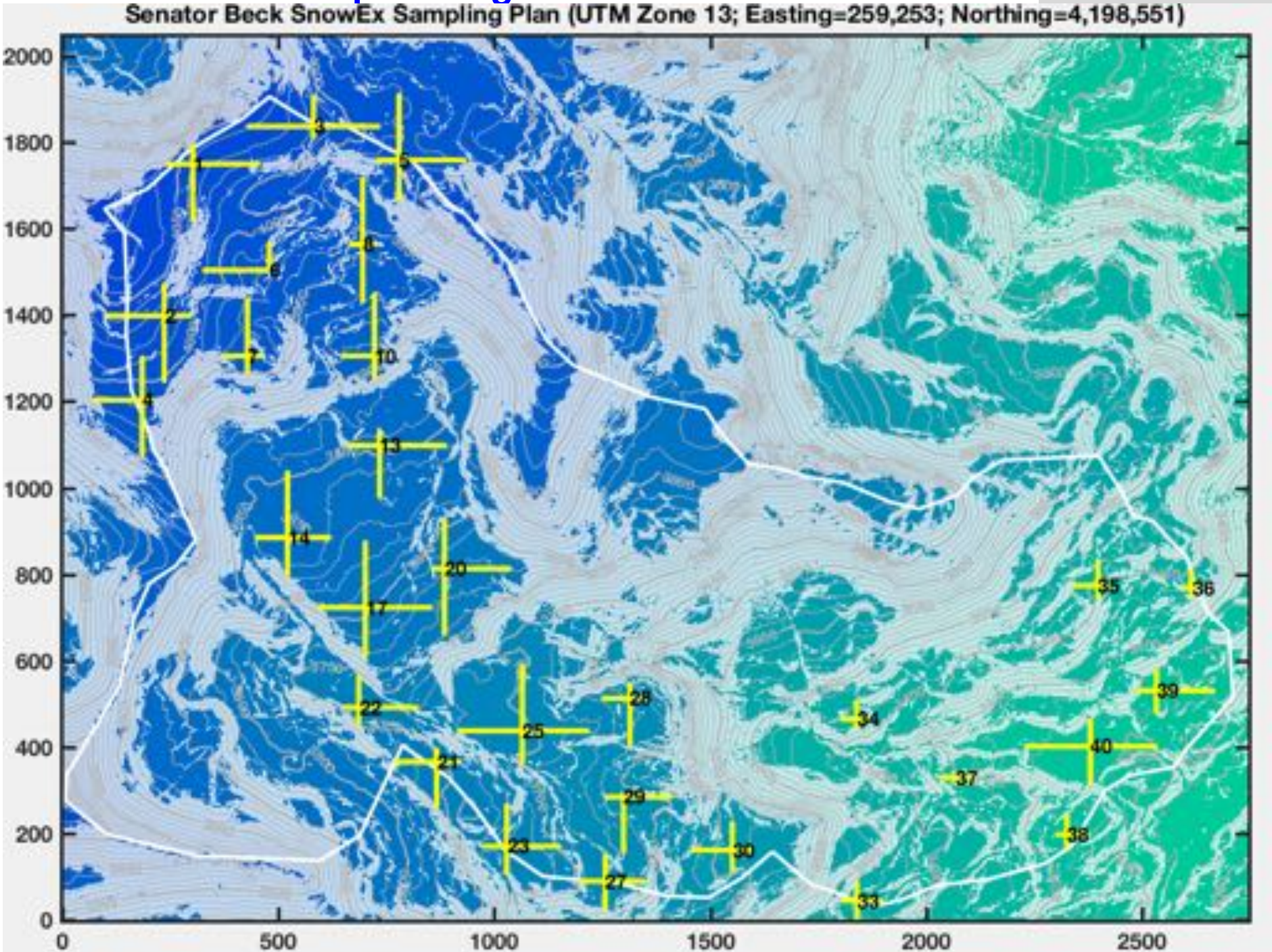
- Pit locations randomly selected, transects in N/S and E/W
- Pits/transects only on slopes $< 25^o$
- Pits required to be $>$ 200 m apart
- Additional pit locations manually removed for safety
- 29 potential safe pit sites; 39 total pits, 44 total transects



Pit and Transect sample design



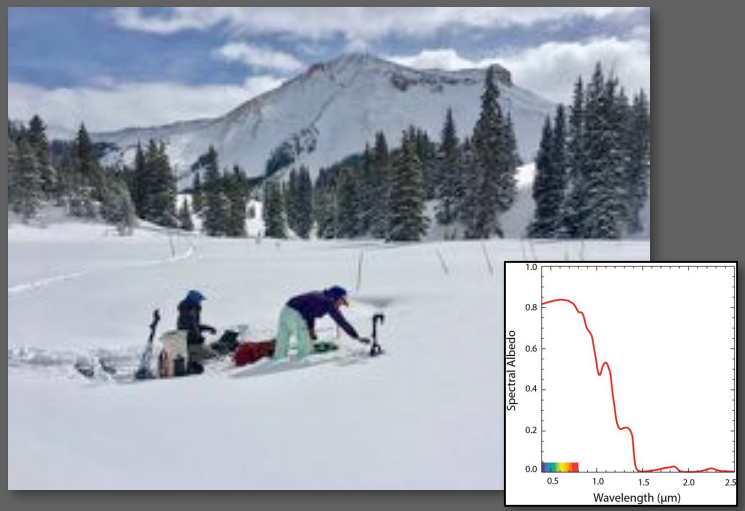
Pit and Transect sample design

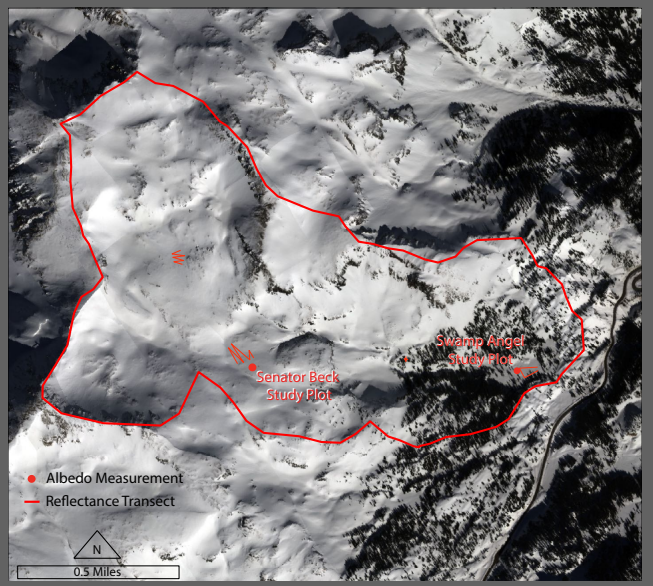


Spectrometer Observations

Senator Beck Basin Week 3 Field Spectroscopy

- Team: McKenzie Skiles and Jewell Lund *(University of Utah)*
- Instruments: ASD FieldSpec4 Full Range, ASD Handheld2 VIS/NIR
- Measurements
  - **Irradiance,** 1x coincident w/ ASO overflight
  - **Radiance,** 2x near coincident w/ overflight
  - **Albedo**, 4x point measurements near instrumentation towers
  - **Reflectance**, 4x transect sets in low/mid basin

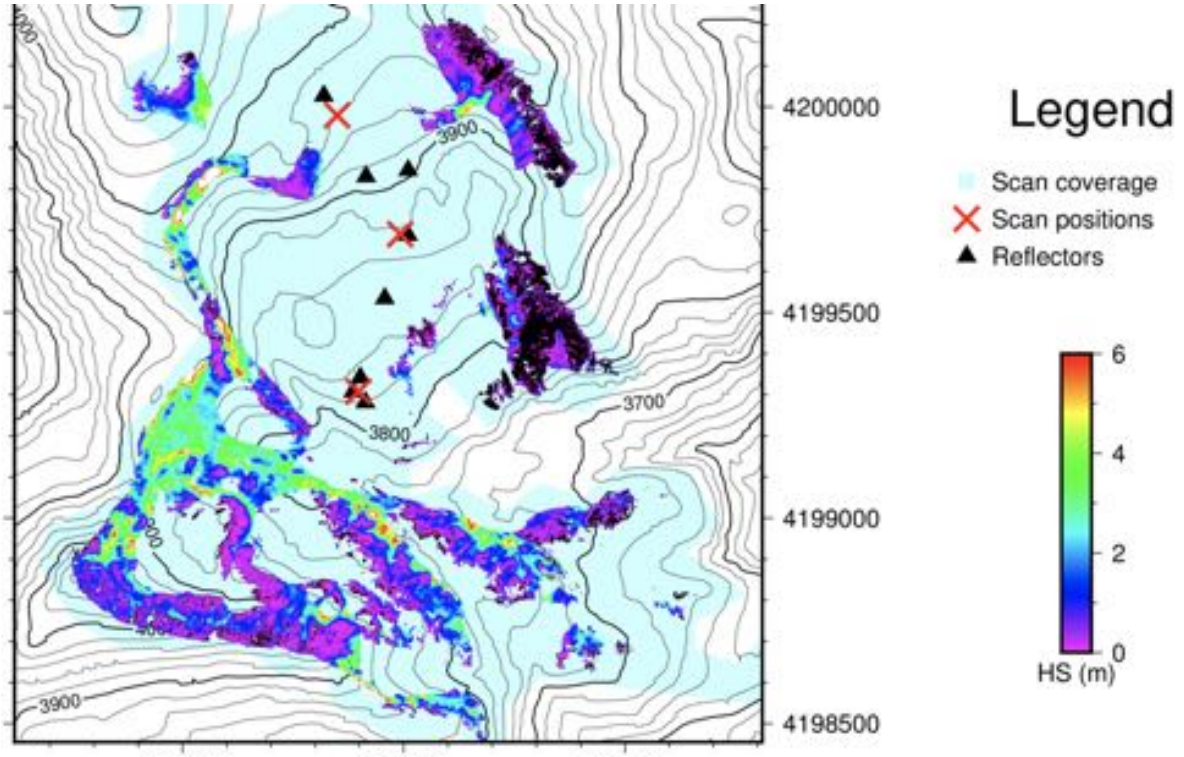




ASO RGB Mosaic (2/21)

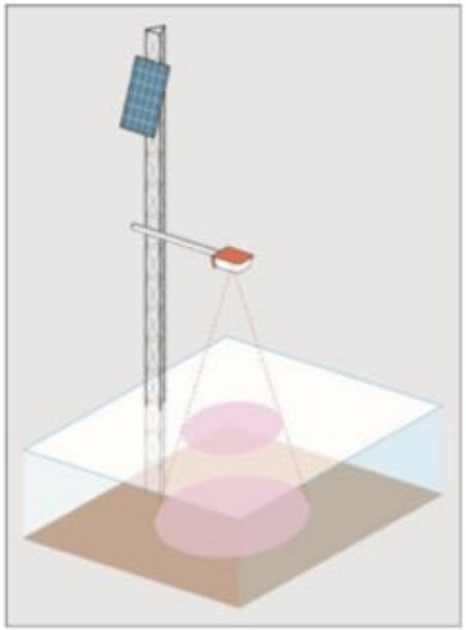
Terrestrial LiDAR Observations

Team: Jeff Deems, Pete Gadomski, Ty Brant



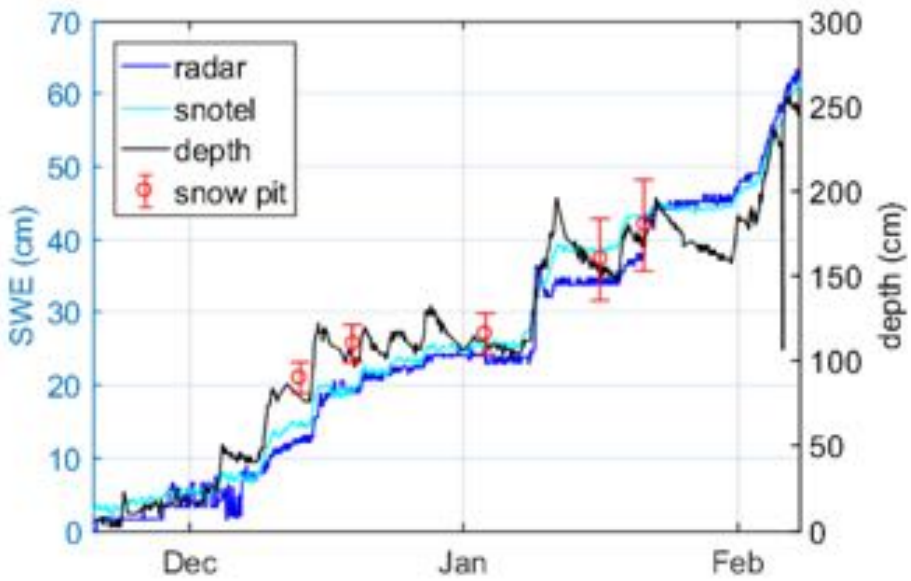
SnowMicroPenetrometer (SMP) Observations

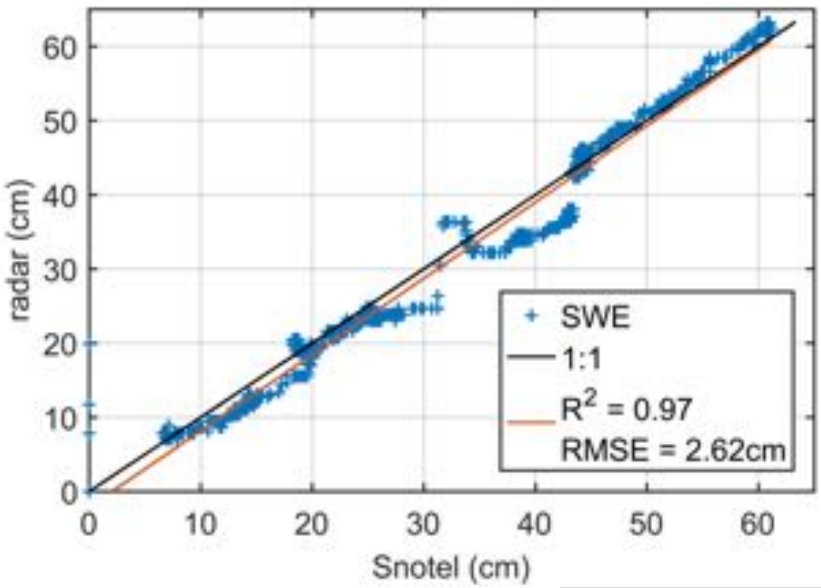
Continuous 1-6 GHz and 24-26GHz tower-based radars



- Downward looking L-,C-band radar for SWE, density, depth, LWC (7 sites in N. America)
- Upward looking Ka-band radar for snowfall (experimental)
- Both radar systems installed at both Grand Mesa and Senator Beck

Continuous 1-6 GHz and 24-26GHz tower-based radars



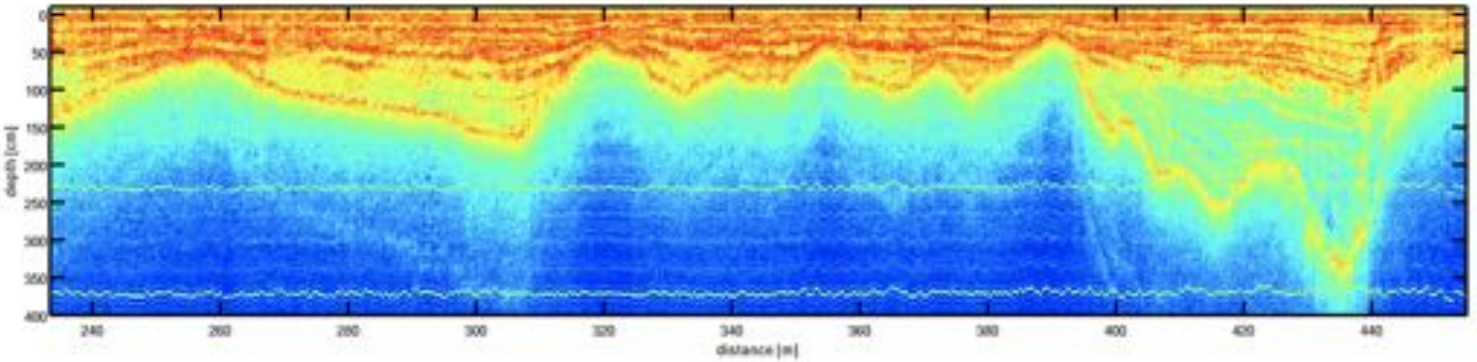


- Example results from Banner Summit, Idaho
- Inversion for SWE not sensitive to settlement / changes in density
- Low cost / low power systems designed for snow application

Mobile Ultra-broadband FMCW radar

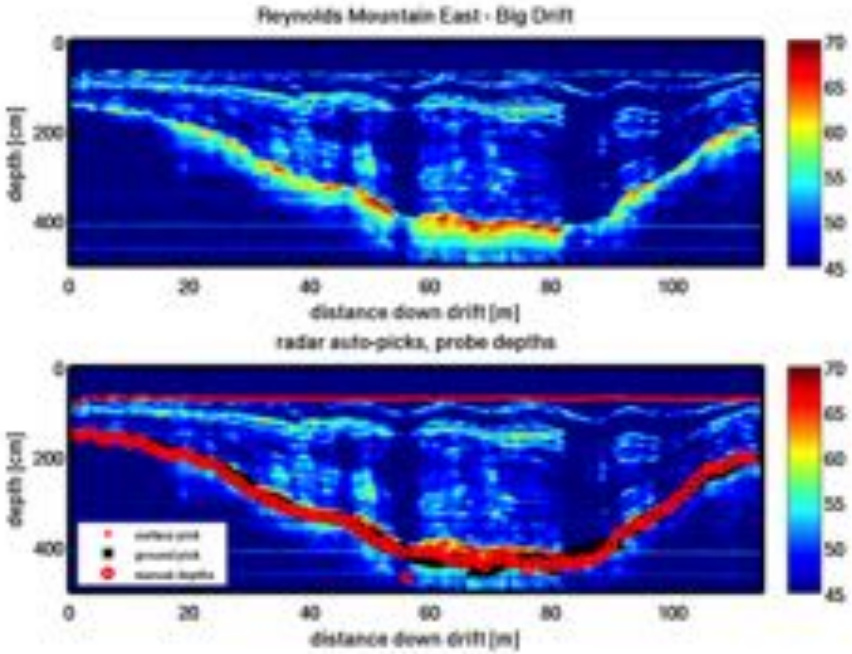
- Frequency range: 6-18 GHz
- Estimates of SWE, depth, stratigraphy, 100 Hz
- Integrated survey-grade (cm) GPS
- Co/Cross-pol channels

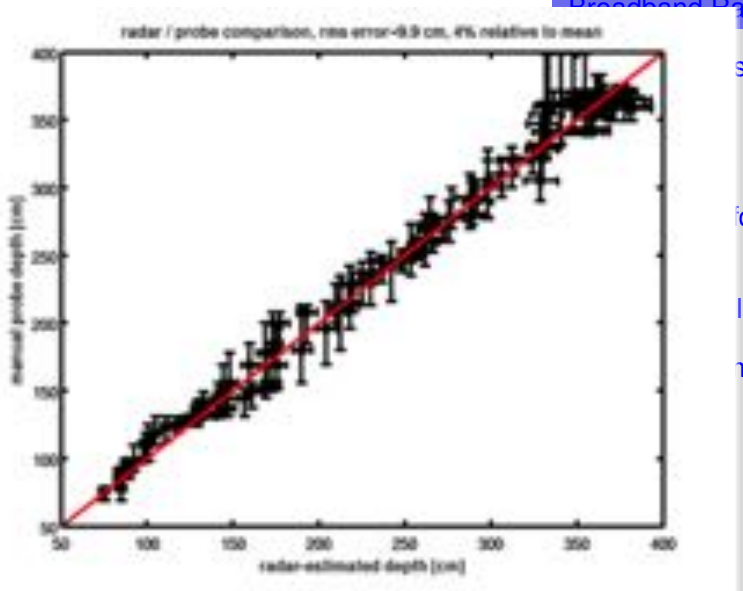
Example FMCW radar profile



(Loading FMCW video)

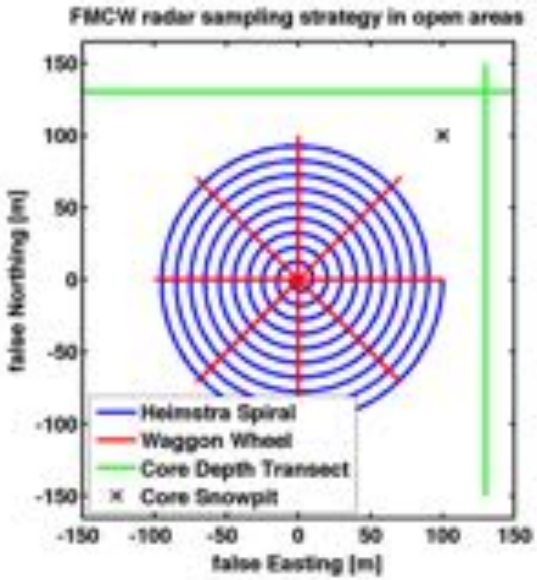
FMCW radar accuracy - depth

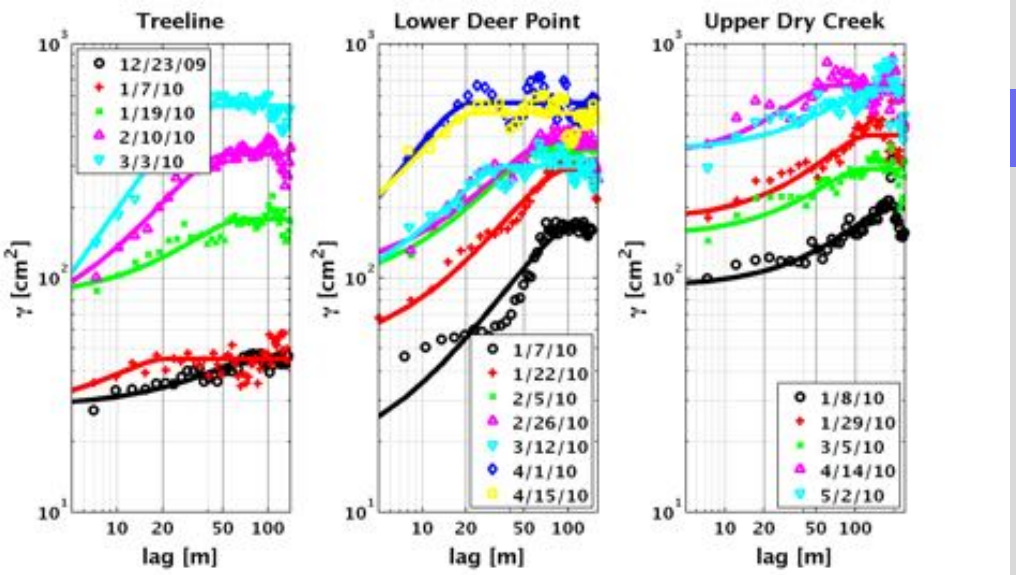




- Radar two-way travel time - convert to depth with density estimate
- Typical accuracy better than 5%
- 12 GHz bandwidth provides 1 cm vertical resolution

FMCW radar sampling strategy





- Radar oversamples along track, and undersamples between transects
- Spatial variability often depends on direction
- *Hiemstra Spiral* removes directional bias

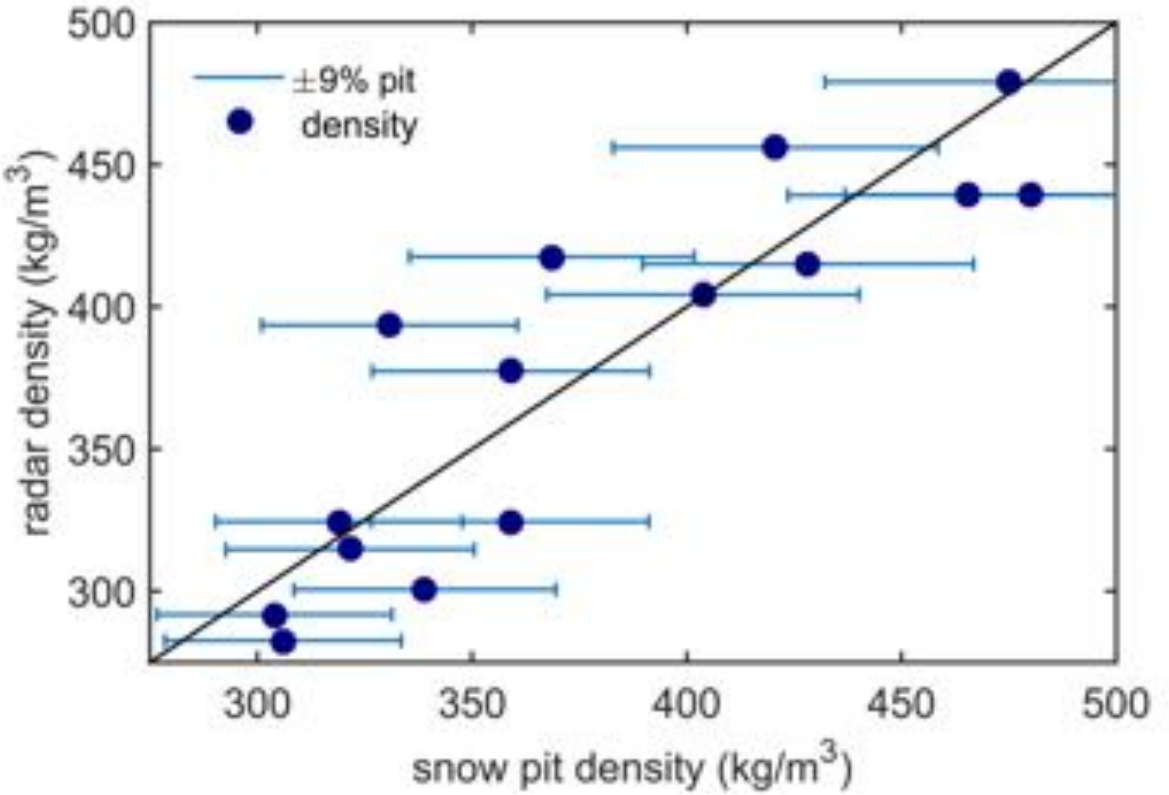
Example FMCW radar profile

(Loading Snowmobile Spiral video)

Example FMCW radar profile

(Loading Ski Spiral video)

Ground-based radar - improved SWE retrieval



Current SWE retrieval methods:

- Depth-based (Airborne LiDAR, TLS, SfM, Ka-band InSAR) – **radar + depth = density**
- Volume-based (X-, Ku-band scatterometers - SnowSAR, WISM) – **radar amplitude**
- InSAR phase (L-Band, UAVSAR) – **radar travel-time**

SnowEx Data Science

- Sensor fusion approach will require complex database structure
- Version control of data and processing code
- Open source SQL
- #SnowExHack, open community project as part of GeoHackWeek 2017

Preparations for SnowEx Years 3-5

- Field measurement protocol: 4th SnowSchool
- Wilderness First Aid, Wilderness First Responder courses
- Avalanche Awareness, Level 1, Level 2 courses
- Take a new course, re-certify during SnowEx Year 2 break!

First iSWGR Meeting, Boulder, CO, Summer 2013

- How well did SnowEx 2017 address gaps?
- What gaps remain that we need to tackle in Y3-5?

Snow science is a team sport!